B-factory Programme Advisory Committee
Focused Review on Online and DAQ Integration Status

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Short Summary

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This review focused on the Belle II online system and the status of the sub-detector integration. The meeting started with a short presentation on the current status and plan of the experiment in general. The sub-detector installation and related commissioning work is progressing well. The detector magnet was switched on for several weeks to measure the magnetic field in the tracking volume. It was then found that the field generated mechanical stress on the photon detectors of the barrel particle identification system, TOP. As a result, a small number of TOP photon detectors moved enough to produce optical decoupling at the PMT/wedge interface and affect the photon detection capability of these detectors. Provided that the number of decoupled PMTs remains small and stable, the over-all deterioration of particle identification in TOP should be small and the collaboration has decided to continue with the detector installation and commissioning. Similar mechanical stress is expected on the ARICH photon detectors too, but studies show that no movement on the photon detectors would occur. The committee supports the decision by the collaboration but urges them to carefully monitor the performance of TOP and ARICH and to develop a repair strategy for possible intervention in the future if the performance deteriorates. The committee also takes note of a tight production schedule for the layer-six of the Silicon-strip Vertex Detector (SVD). There was a setback in the production of readout ASIC chips for the Pixel Detector (PXD) resulting in a delay of three months for the start of the installation of the Vertex Detector system (VXD), i.e. PXD and SVD, to Summer 2018.

The Belle II online system performs many functions. It generates the trigger signal based on the K_L-muon detector (KLM), Electromagnetic Calorimeter (ECL), TOP and Central Drift Chamber (CDC), and distributes the readout timing signal. It also controls the data acquisition, operates the detector by controlling and monitoring the functionalities of the sub-detectors as well as providing the machine-related parameters near the interaction point to the machine group. The overall system is well designed and implemented by a relatively small number of competent people working very effectively and also providing services to the sub-detector groups who are responsible for commissioning and integration of their system into the central Belle II online system. The general framework is ready for the integration work by the sub-detector teams.

In the Belle II data acquisition system (DAQ), the front-end electronics of all sub-detectors, except the PXD, are read out by common custom-made boards (COPPER) through optical cables with a common protocol followed by the first level of event building without PXD based on off-the-shelf equipment. A scaled down version of this system, so called POCKET DAQ, is provided by the online team for the sub-detector groups. The POCKET DAQs are being used for the standalone commissioning of the individual sub-detectors in a way compatible with the central Belle II DAQ system. This is an excellent idea and has allowed a smooth transition from the commissioning of individual detectors to the integration of the entire system. Several sub-detectors have already been successfully integrated into the central DAQ system. The forthcoming important milestone is the global cosmic-ray run starting in April 2017, initially with all the installed subsystems but the ARICH and Forward End-cap ECL, which will join for the second campaign taking place in the second half of 2017. After the standalone cosmic-ray run, the VXD placed outside the Belle structures will join the global cosmic-ray run followed by the installation in Summer 2018.

With the information from the first level of event building, an event is fully reconstructed for an event selection (HLT) and track parameters are sent to a dedicated PXD readout electronics (ONSEN). Using those parameters, narrow regions of interest (RoIs) are defined in the pixel sensors, whereby only the clusters inside of the regions are read out in order to reduce the amount of data by a factor of ten. These clusters are then added in the second level of event building and the complete event is sent to a storage device. This readout scheme, based on RoIs, was successfully tested during test beam data taking at DESY with a VXD prototype, using SVD data to define the RoIs. The HLT structure has been well designed and implemented, and benchmark algorithm studies show very encouraging results.

The Belle II experiment deploys NSM2 and EPICS for the Slow Control system. The former is the main system for the experiment also used by the Run Control. The latter is used by the VXD and related items such as the CO_2 cooling system where much of the control software already exists in EPICS. EPICS is also used by the SuperKEKB machine. A gateway was made connecting the two systems and a common user interface is being developed using a stylesheet language, CSS, for the controlling and monitoring of the sub-detectors.

The committee congratulates the central online team for the successful implementation of the complex online system for the Belle II experiment. It is now important to prepare for stress tests of the system with the complexity, size and rate of data following realistic patterns expected from the experiment. The global cosmic-ray test in 2017 will be an ideal occasion. The committee considers that the size of the central online team is worryingly small. In addition to finding more people for the team, DAQ experts of the sub-detector groups are encouraged to extend their scope to some of the central online work in parallel with the integration work of their sub-detectors.

The committee recognises the practical reasons for deploying NSM2 and EPICS for the Slow Control system. However, the overhead required to integrate and maintain two systems smoothly in a coherent manner should not be underestimated. Special care must be given to the user interface so that all sub-detectors are controlled and monitored in a unified manner independent of hardware differences. Continuous discussion must be maintained with the machine group to identify necessary information from the experiment for optimising the machine operation. It should be noted that some of those inputs may need to be provided with a much higher rate than usually foreseen in a slow control system. For the interlock system, the committee recommends case studies of the system behaviour for all possible incidents in order to ensure the safe operation of the experiment and machine. It is important that some of the machine elements in the detector, such as the superconducting focusing magnets, should be taken into account in the studies.

In the KLM system, the operation procedure of the newly installed scintillator detector and existing Resistive Plate Chamber detectors must be well integrated. A detailed plan for the overall commissioning and integration of the system is still missing. The ECL system is at a very advanced state and it would be useful to test the longterm stability of the DAQ and Slow Control systems with this sub-detector. The CDC is also in an advanced state and the committee is looking forward to seeing tests with more channels. The progress made by the TOP group was impressive including the recent advancement in the firmware development. The committee encourages the group to keep the momentum for the commissioning and integration effort. An intense firmware effort is still required until feature extraction is operational and the TOP is integrated into the central DAQ system. The committee encourages the ARICH group to advance with the purchase of the high-voltage cables and power supplies, which limit the scale of the commissioning activities. Compared to the effort still needed for the DAQ integration, human resources allocated appear to be too small and the committee suggests the ARICH group and the Belle II collaboration address this issue. Operation of the SVD and that of PXD are very closely related and coherent operation procedures must be developed in a close collaboration. A system test of VXD with the Permanent Running System at DESY (PERSY) should be fully exploited for this purpose and it will also help for validating the readout electronics and providing smooth integration of the VXD system into the central DAQ system.